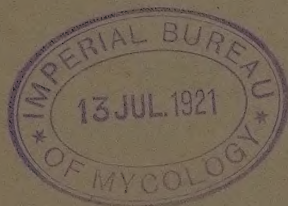


FLORA W. PATTERSON.

POTATO DISEASES IN NEW JERSEY.

M. T. Cook + G. W. Martin.



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NEW JERSEY

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NEW JERSEY

AGRICULTURAL EXPERIMENT STATIONS

CIRCULAR 33

Potato Diseases in New Jersey.*

Potato growing is one of the most important industries in New Jersey. In 1912 there were 92,000 acres in potatoes producing 9,936,000 bushels, or an average of 108 bushels per acre. This crop sold at an average of 66 cents per bushel, which was \$71.28 per acre, or \$6,557,760 for the entire crop. The loss due to preventable diseases did not attract a great deal of attention. The loss in 1913 was much greater, being not less than 25% of the total valuation of the crop, which, if estimated on the same basis as in 1912, would amount to \$1,639,440. This loss could have been greatly reduced by treating the seed with formaldehyde or corrosive sublimate.

It is very generally recognized that the reduction in the potato crop is due primarily to three causes: unfavorable weather, insects and diseases. The weather conditions are beyond our control, except where methods of cultivation may help to conserve the moisture or where irrigation can be used to advantage. The most injurious insects are quite readily controlled but the methods may be improved as the result of future experimental work. The diseases caused by fungi and bacteria are much more difficult to control and are the causes of the greater part of our losses. Some of these diseases are carried on the seed and can be controlled by the use of formalde-

* Prepared by Mel. T. Cook, Ph.D., and G. W. Martin of the Department of Plant Pathology, New Jersey Experiment Station.

hyde or corrosive sublimate, while others persist in the soil and are not so readily prevented.

The weather conditions in New Jersey during the season of 1913 were exceptionally unfavorable for potatoes. A warm period in March, which opened the fruit buds and advanced vegetation in general much earlier than usual, was followed by two weeks of cold, wet weather. Many growers, tempted by the early season and the good condition of the ground, planted their potatoes in the middle of March and when the cold and wet weather came, the seed pieces were unable to germinate. Many of them rotted completely in the ground. In others a rot was started, which, while it did not prevent them from sending up shoots, did succeed in so weakening the plants that they readily succumbed to the dry weather which followed and to other diseases. This rotting was due to *Bacillus vulgaris* Hauser as described later in this bulletin. Following the wet spell, two weeks of favorable weather brought the early plantings above ground. Many growers planted at this time and these plantings were far more successful than the earlier ones. When some of the early plantings were from four to six inches above ground there were several nights in which frost occurred. Plantings in all parts of the State were severely cut back. A period of favorable weather following promised to partly repair the damage from frost, but practically no rain fell from May 28th to June 20th, and toward the latter part of this period the potatoes, and particularly those on the lighter soils which dried out quickly, began to suffer severely from drought and disease. The condition was made worse by the fact that in many localities the rainfall had been so heavy during the cold, wet period following the early plantings that the ground was watersoaked and the plants more shallow-rooted than usual, and less able to stand the drought. In their weakened condition they were readily attacked by disease.

Another important factor contributing to the poor crop in 1913 was the unusually poor quality of the northern-grown seed used, a large proportion of it being affected with silver scurf, bacterial rot, late blight, *Fusarium* stem blight or dry rot, and black leg.

The tendency of the grower is to refer to all dying of the plants as "blight", but the diseases described in the following pages will indicate the large number of diseases other than blight that are already in the State, as well as several others which may be expected to appear at any time.

Bacterial Rot.

It is well known that cold weather at the time of planting will cause seed potatoes to rot in the ground. In March, 1913, we received several complaints, not only that seed was rotting in the ground, but that it was rotting before planting. An investigation showed that certain shipments of Maine seed contained rotting potatoes. The rot converted the diseased parts into soft slimy

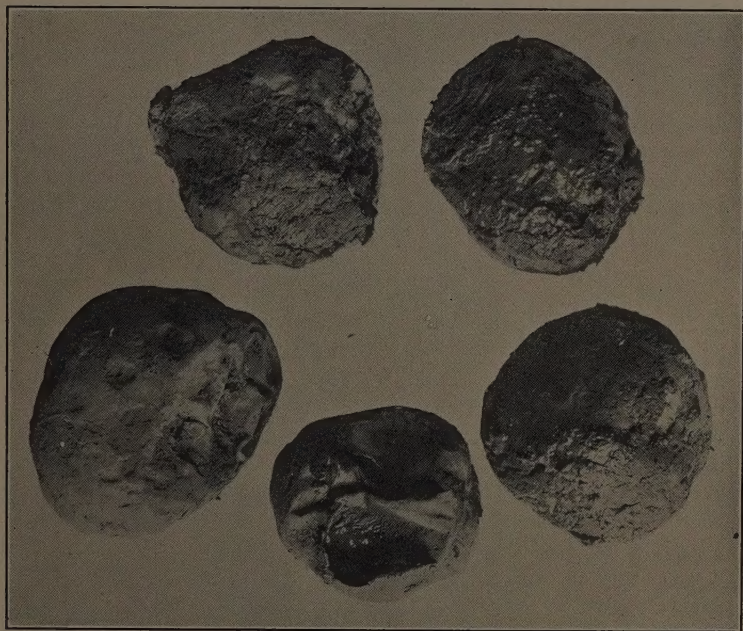


FIG. 1. BACTERIAL ROT OF SEED POTATOES.

masses containing millions of bacteria. This substance was smeared over the surface of the sound potatoes in such a shipment, with the result that when the latter were cut for seed, the cut surface became infected by the knife and decay followed, beginning in spots. (Fig. 1). The early planting of these potatoes did not give as good stands as the plantings from sound seed made at the same time, but plantings made from this same seed two weeks

later, when the weather was much warmer, gave good stands. The decay was apparently due to *Bacillus vulgaris* Hauser, an organism which grows at a lower temperature than that necessary for the germination of the potato. It is evident that during cold weather the germination of the seed would suffer a greater checking of growth than the organism, thus permitting a decay of the seed pieces before the young plants could become established. This rot was the cause of much of the poor stand and of many weakened plants which could not survive the dry weather and later attacks of insects and fungi.

Control.—Although the weather is the most important factor in the control of this trouble, the loss can be reduced by treatment of the seed with formaldehyde, and by dipping the cutting knives in a 25% solution of the same. This may be easily accomplished by having two knives for each cutter and letting one stand in the solution while the other is being used. This precaution has been adopted by many of the northern growers.

Southern Bacterial Wilt.

This disease, also known as the "sleeping sickness", is caused by *Bacillus solanacearum*, E. F. Smith. It attacks potatoes, tomatoes, egg-plants, peppers and tobacco (on which it is known as the Granville tobacco wilt) and is one of the most destructive diseases of the southern states. It was reported in 1903 as attacking tomatoes in this State. It is especially severe in dry seasons and on dry soils. It was very severe on the potatoes in the southern part of the State in 1913 and aside from weather conditions caused greater injury to the early Cobblers than any other one factor. The disease was decidedly more severe on eastern seed than on New Jersey grown seed, and there was a slight amount of evidence tending to show that it was less severe on seed which had been treated with formaldehyde than on seed which had not been treated. The evidence on this point is, however, far from conclusive. It was severe as far north as Burlington, northward from which point it decreased in severity.

The disease first appears as a wilting, followed by a revival at night and a wilting the second day. Plants very seldom survive the second day's wilting unless there should be intervening rains, but become yellow and blacken, and the tubers rot readily. The disease is carried by insects and in the seed, and in the southern states, in

the soil. It is probable that the cold weather of the north checks it to some extent, but this point has not been demonstrated.

Control.—Tubers from diseased vines should not be used for seed, and rotation of crops should be practiced. Other crops which are attacked by the disease should not be used in the rotation.

Black Leg.

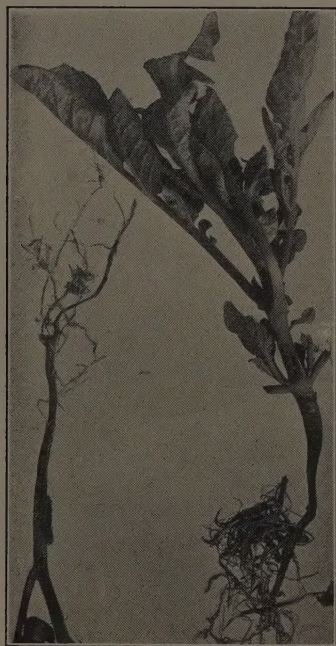


FIG. 2. BLACK LEG.

From Farmers' Bulletin 544, U. S. Dept. of Agriculture.

This is one of the severe diseases of the potato which comes to us on the seed and was quite severe throughout the State during 1913.

It is caused by *Bacillus phytophthorus* Appel, and originally came from Europe. The affected plants are undersized, very erect, pale in color and the leaves tend to curl upward. (Fig. 2). The stems below ground and for a short distance above ground, be-

come black and decayed. The organism is said not to persist in the soil in the northern potato growing districts. Black leg was much more severe on plants grown from eastern seed than on those grown from second crop New Jersey seed. The disease also causes a rot of the tuber (Fig. 3).

Control.—Seed treatment with formaldehyde or corrosive sublimate.

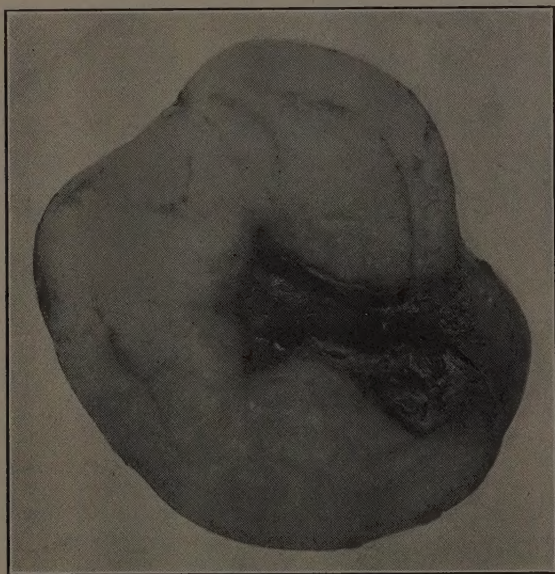


FIG. 3. TUBER ROT, DUE TO BLACK LEG.

From Farmers' Bulletin 544, U. S. Dept. of Agriculture.

Scab.

This is one of the most common and best known of the potato diseases and yet one which is very generally neglected by the growers. (Fig. 4). It is caused by *Oospora scabies* Thaxt, and is carried on the seed, in the dust on healthy tubers and in manure from animals fed on diseased tubers, and persists in the soil. It is most severe in alkaline soils, and growers should therefore avoid the use of lime, wood ashes, soda, and stable manure on potato lands unless applied with other crops. The disease also occurs on beets, turnips, cabbage and some other plants.

Control.—(a) Select smooth seed, (b) disinfect with formaldehyde or corrosive sublimate, (c) plant in clean soil following a green crop, (d) avoid alkaline fertilizer, (e) do not plant on infected soil for three to five years, (f) do not use beets, turnips or cabbages in the crop rotation.



FIG. 4. SCAB.

Russet Scab.

A peculiar russetting has been reported from many parts of New Jersey. We have been unable to determine the cause, but it appears to be very generally associated with the scab. It is one of our problems for further study.

A russet scab has been reported as more or less common in the West and has been attributed to the *Rhizoctonia* fungus, but has not been thoroughly studied.

Powdery Scab.

This disease is quite different from, but resembles the common scab, and is caused by a fungus (*Spongospora subterranea* (Wallr.) Lag.), which has recently been introduced into Canada from Europe. It has also been reported from two or three places in the United States, but so far there is no evidence that it has become established. The European reports indicate that it is a very serious disease. The spots are covered when young but when mature, break into brown, powdery masses. It is extremely difficult for the inexperienced person to detect this disease from the common scab. Thus far no satisfactory method of seed treatment has been devised. When the soil is once infected it requires several years' rotation of crops to eradicate the organism. The United States Government prohibits the importation of potatoes from foreign districts known to be infected with the disease. Our growers should take every possible precaution to guard against the introduction of this disease into New Jersey. The fact that we import practically all our seed from other states keeps us in constant danger of the introduction of this pest. It is unwise to buy seed potatoes from localities where the disease is known to exist; examine the seed carefully before planting; treat the seed with formaldehyde or corrosive sublimate even though neither of these treatments is an absolute preventative.

Potato Wart.

This is one of the most important European diseases. It is caused by a fungus (*Synchytrium endobioticum* Perc.), and is extremely difficult to control. It has been introduced into Newfoundland. On the severely affected tubers it causes coral-like, scaly nodules, which are readily recognized. Seed potatoes may be slightly affected and escape notice. The danger of the introduction of this disease has been greatly reduced by the quarantine which the United States Department of Agriculture has placed on all foreign countries in which it is known to exist. However, our growers should be constantly on the lookout for it.

Scurf.

This widely distributed disease occurs under several different forms and is known under correspondingly different names as

"rosette," "stem rot," "little potato" and "aerial potato." (Fig. 5). All of these forms have been abundant during the past season, especially on late potatoes. The disease is caused by the fungus *Corticium vagum* B. & C. var. *solani* Burt. Some of the symptoms are common to other diseases, and this no doubt frequently leads to some confusion. Affected plants may ordinarily be recognized by the peculiar curling and twisting of the foliage. A leaf roll dis-

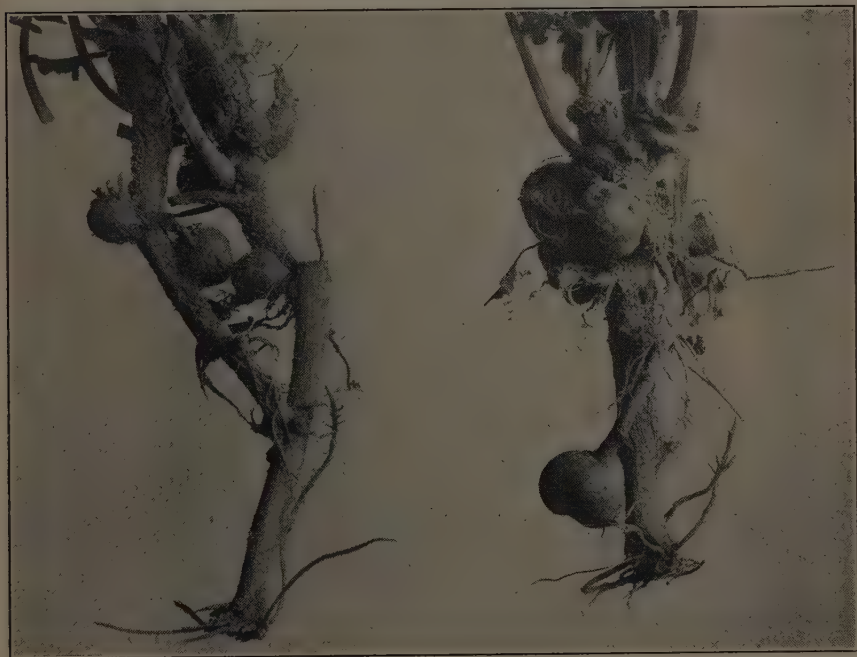


FIG. 5. LITTLE POTATO AND AERIAL POTATO.

ease has been reported from Europe and from certain of our western states. It has been attributed to the same cause as the scurf, to stem blight and to Fusarium wilt, but is now thought to be purely physiological. We have no reason to believe that this trouble exists in New Jersey as in nearly all cases we have been able to find the fungus on our diseased plants. The product of scurf plants is usually very much reduced, most of the tubers being

undersized. Sometimes there will be one or two large tubers and a number of small ones in the hill, and frequently nothing but a large number of very small potatoes clustered close around the main stem. This symptom is also common on plants that have been injured by frost or attacked by black leg. The diseased tubers show small white spots composed of masses of the fungus mycelium and are sometimes covered with a delicate fungus growth. These white spots become black in storage and are known as sclerotia. It is by means of these sclerotia that the disease is carried over from season to season. (Fig. 6.)

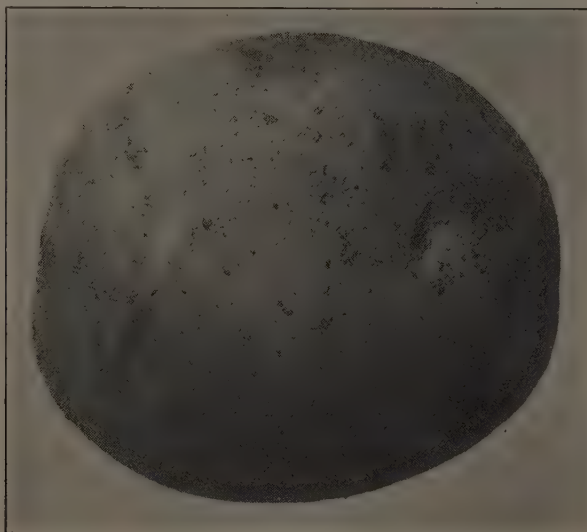


FIG. 6. TUBER COVERED WITH SCURF SCLEROTIA.

Control.—Use clean seed and practice rotation of crops. Treatment with formaldehyde will probably reduce the disease, but it is doubtful if it will eradicate it. Corrosive sublimate is much more satisfactory.

Silver Scurf.

This is a new fungus disease (*Spondylocladium atrovirens* Harz), introduced from Europe. Great quantities of the seed potatoes brought into New Jersey in 1913 were affected with it, the dis-

ease appearing as small dark spots on the skin. In storage, these spots enlarge, and the tuber shrivels and becomes somewhat silvery in appearance. (Fig. 7).

Control.—It is very doubtful if this disease can be controlled by seed disinfection, hence seed selection is the only alternative.



FIG. 7. SILVER SCURF.

Dry Rot and Wilt.

This is a very common and widely distributed fungus disease of the potato, caused by *Fusarium oxysporum* Schlecht and frequently referred to as "Fusarium wilt" and "stem blight." It can be recognized in the tuber by the black discoloration starting at the stem and just below the peel. This disease causes a dry rot in winter storage. In the field the diseased plants wilt and die prematurely, the stems blacken and rot at the surface of the ground, and are frequently covered with a delicate white or pink fungus growth. When the diseased stems are cut across, the fibro-vascular bundles are found to be black and dead. (Fig. 8.)

Control.—Throw out all seed that shows black discolorations when cut. Use a five year crop rotation for infected fields.

Other Dry Rots.

Other species of *Fusarium* are the causes of storage rots. Among the most important are *Fusarium trichothecioides* Wr., which causes a powdery dry rot in the western states and *F. tuberivorum*

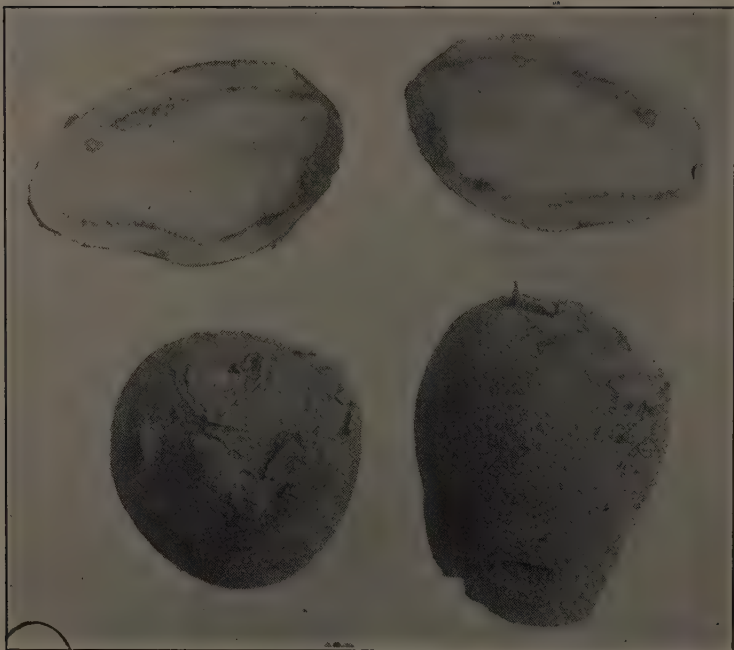


FIG. 8. FUSARIUM ROT.

Wilcox, which causes a dry rot in Nebraska. These rots have not been reported from New Jersey.

Verticillium Wilt.

- This is due to a fungus (*Verticillium albo-atrum* Reink and Berth) and is very similar to the Fusarium wilt. The black discoloration of the tuber is much more pronounced than in the case of the Fusarium wilt and the wilting is more rapid. It is not so common nor so widely distributed. We have not found it in this State.

Early Blight.

This very common and widely distributed fungus (*Alternaria solani* E. & M., J. & G.), attacks both potatoes and tomatoes and is frequently the cause of heavy losses. It appears as dark, grayish

spots on the leaves, within which are delicate, black, concentric circles. These spots increase in size, and unite, forming irregular blotches and frequently destroying the entire leaf. Flea beetles and other insects carry the disease from plant to plant. This disease is not apt to be serious on vigorous, well-fed plants.

Control.—Spray with Bordeaux mixture or other good fungicide.

Late Blight.

This, one of the most destructive diseases of the potato, is caused by the fungus *Phytophthora infestans* De By. It is common in northern potato growing districts and in the mountainous districts of the southern states. It is especially severe in cool, moist weather, frequently causing the foliage to wilt and blacken in a

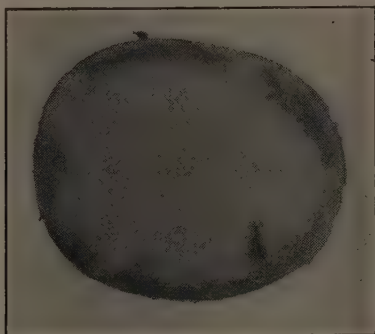


FIG. 9. LATE BLIGHT DRY ROT.

From Farmers' Bulletin 544, U. S. Dept. of Agriculture.

very few hours. It also causes a soft tuber rot in the fields and a dry brown rot in storage. (Fig. 9). It is occasionally severe in New Jersey and always occurs to some extent in the mountainous districts. Some shipments of northern seed potatoes into New Jersey in 1913 were affected with this disease.

Control.—Throw out all infected seed, i. e. tubers showing brown discolorations when cut. Spray with Bordeaux mixture or other fungicide, the same as for early blight.

Arsenical Poisoning.

Spotting and dying of the foliage is frequently caused by the application of Paris green or other arsenical poisons. It is fre-

quently mistaken for blight and injures the plant in proportion as it reduces the amount of green surface. The injured foliage also offers favorable opportunities for the development and spread of the early blight.

Control.—Paris green should always be mixed with lime, whether applied dry or in water. It can be applied with Bordeaux mixture without additional lime. Arsenate of lead can also be applied with Bordeaux mixture. The latter spreads and sticks better than Paris green, but acts more slowly.

Tip Burn.

This is due to the hot, dry mid-summer weather. It causes the leaves to die, beginning at the tips and margins, the stems holding their normal position. It is often caused by applying a wet spray to the vines under a hot sun.

Control.—Plant on soil rich in humus and give good surface cultivation to conserve the moisture. Irrigate where possible. Spray with Bordeaux mixture in order to keep the foliage in healthy condition. Do not use a wet spray in bright sunlight.

General Treatment.

Healthy, vigorous and well-fed plants are much less subject to certain diseases than plants which are neglected and ill-nourished or are growing under unfavorable soil or climatic conditions. Given proper soil, containing an abundance of plant-food, and suitable climate, certain sanitary precautions are necessary to insure plants able to resist the attack of disease and to produce a maximum crop. First treat all seed potatoes with formaldehyde* or corrosive sublimate. No matter how pressed the grower may be for time and labor, it is poor economy for him to run the risk of infecting his soil with dangerous diseases when this simple precaution will protect him. The standard way to use this preparation has been to soak the seed for two hours in a solution of one pint of formaldehyde to thirty gallons of water. This, while very effective, is somewhat slow and laborious, and many growers are using formaldehyde gas with good results. This method requires a chamber that is practically air tight. For each 1000 cubic feet in such a chamber, 23 ounces of potassium permanganate and three pints of

* Formaldehyde and formalin as recommended for disinfecting purposes, are the same thing. Strictly speaking, formaldehyde is a gas, and the commercial preparation is a 40% solution of this gas in water. This 40% solution is what is meant in this circular.

formaldehyde are required. The permanganate is spread in a good-sized tub, so that it barely covers the bottom, and the formalin is poured over it. The door should be tightly closed for twenty-four hours, after which the potatoes may be cut.

While it is most convenient to have a regular fumigating house for this operation, any chamber will do, the only requirement being that it must be airtight. Many farms have an old out-building or a spare room or a part of the cellar which can be made satisfactory by the judicious use of building paper, while a building especially for this purpose may be erected of rough lumber and lined with building paper at a very moderate cost. The most satisfactory and permanent form of disinfecting house would be constructed of concrete, and while its first cost would be somewhat higher, it might prove a profitable investment for someone in every community where potatoes are grown, as it would serve to disinfect not only the owner's seed potatoes, but those of his neighbors as well. In using the formaldehyde gas, the potatoes should be placed in racks or in baskets and piled so as to permit free circulation of the gas. If in bags, they should be laid in rows with spaces between the bags, and 2 x 4 scantlings should be laid between the different rows in a pile. Care should be taken to have no potatoes within three feet of the generating tub or directly over it.

Caution: Reports from some states indicate that seed potatoes are sometimes injured by the formaldehyde gas. This is more likely to occur when the fumigating room is not well filled with potatoes, owing to the tendency of a few potatoes to absorb an excessive amount of gas. Injury is also more likely to occur on sprouting than on dormant potatoes. The injury appears as sunken brown spots and in some cases will prevent germination. Mild injury will not necessarily reduce the vitality of the tubers.*

Corrosive sublimate is frequently used instead of formaldehyde. It has the advantage of being much more effective for scurf (*Rhizoctonia*) than the formaldehyde. Soak the seed tubers for 1½ hours in a corrosive sublimate solution (4 ounces corrosive sublimate in 30 gallons of water.)

Caution: Do not mix the solution in a metal container. Corrosive sublimate is a deadly poison and must be kept out of reach of children and irresponsible persons.

* The writers are indebted to Mr. F. C. Stewart of the New York Agricultural Experiment Station, at Geneva, N. Y., for this information concerning the injury due to formaldehyde gas and the value of formaldehyde and corrosive sublimate for the control of scurf.

Seed disinfection will merely clean the surface of the tubers. It is necessary to guard against infection carried in the seed. To this end, all tubers showing marked discolorations of any kind when cut should be promptly discarded, and the cutting knives should be frequently disinfected or changed, as suggested on page 6.

Several diseases are carried by insects, and by keeping these pests in check the spread of these diseases is likewise checked. Many growers make a practice of letting the Colorado beetles become very numerous before applying poisons. This is a mistake, as it is much easier to control them while they are few in number, and at the same time the chances of carrying infection are reduced.

Cultivation is not ordinarily regarded as a sanitary precaution, but it is such, nevertheless. By keeping the soil loose as close to the roots as possible, it is not only kept in condition to permit the freest possible growth of the plants, but moisture is conserved. Plants suffering from drought are especially susceptible to the attacks of early blight and sleeping sickness, and a well-tilled field is often practically free from these troubles, while a poorly-tilled neighboring field is badly infected.

Finally, treat the field with a combined insecticide and fungicide. This is done with both wet sprays and dry dusts. The latter are still in a considerable degree in the experimental stage, and while there are several commercial Bordeaux mixtures on the market which have given satisfaction where used, it must yet be shown that there is anything more satisfactory on the whole than the old-fashioned, home-made Bordeaux and Paris green. This mixture has a greater stimulating effect on the vines than either the commercial Bordeaux or the dust preparations, and while it has not been effectual in controlling the flea beetle during the past season in this State, it remains the best remedy for this pest that has yet been discovered, and where proper facilities for mixing are provided, it is easy to mix and apply. It has the further advantage of being very much cheaper than any of the other preparations.

For Potatoes, use a 5-5-50 mixture; that is, 5 lbs. of copper sulfate and 5 lbs. of lime to 50 gallons of water. Place the copper sulfate in a cloth bag and suspend near the top of the water in a tub, where it should dissolve in a few hours. Use good quicklime and slake slowly with a minimum quantity of water, dilute to 25 gallons and strain, using a strainer with not less than 18 meshes to the inch. Dilute the copper sulfate solution to 25 gallons and add

together the two *dilute* solutions to make 50 gallons of the mixture. It is well to have the lime slightly in excess. To test for excess of copper, take a glassful of the mixture and add to it a few drops of a solution of yellow prussiate of potash. If this causes the formation of a dirty green precipitate it means that free copper is present and that more lime should be added. Where much of the mixture is to be used it is usually advisable to make up stock solutions. Shake the lime in a flat box and add enough water to bring it to the consistency of putty. Cover with more water to keep out the air. The amount of paste to use to the barrel can be easily estimated. Dissolve the copper sulfate at the rate of one pound to the gallon of water. These preparations can then be diluted and added together as needed. For the control of bugs, add to each 50 gallons of the Bordeaux mixture, 1 lb. of Paris green or 3 lbs. arsenate of lead paste.

The seed problem is an acute one in this State. There can be no question but that many very serious diseases have come to us within the last few years on northern grown seed, and more may be confidently looked for in the future. Many growers of early potatoes in the southern part of the State use what is known as second crop New Jersey seed. This is grown from northern seed, purchased in the fall and kept in cold storage until after the main crop has been harvested, then planted, usually in the same field, and the resulting crop used for seed the following year. While this practice was adopted for the purpose of reducing the cost of northern seed, by making a given amount go farther, it seems to possess decided advantages from a sanitary standpoint, the crops grown from such seed often being noticeably freer from disease than the crops grown directly from the northern seed. At least such seed is grown under the immediate supervision of the grower and he can determine whether or not the resulting plants are diseased. It has been suggested that some system might be devised whereby the fields in which the northern seed is grown might be regularly inspected for disease, and when found to be free, properly certified. Meanwhile, the grower must depend upon careful selection, disinfection, and a rigid elimination of all suspicious looking seed, when cut.

A simple form of fumigating house is shown in the plan given in Fig. 11. The framework may be made of 2 x 4 spruce, over which any cheap boarding may be used, provided it is free from knots and tongued and grooved so that the boards may be

tightly fitted together. Shiplap is not desirable. The building is rendered airtight by tarred paper and laths, or better still, by a lining of rubber roofing. Great care is necessary in constructing the door and window. These should be at least three layers of board thick and should fit into the frames very tightly, as indicated in the detail sketch. It should be possible to open the window as well as the door from the outside so that the building may be quickly aired

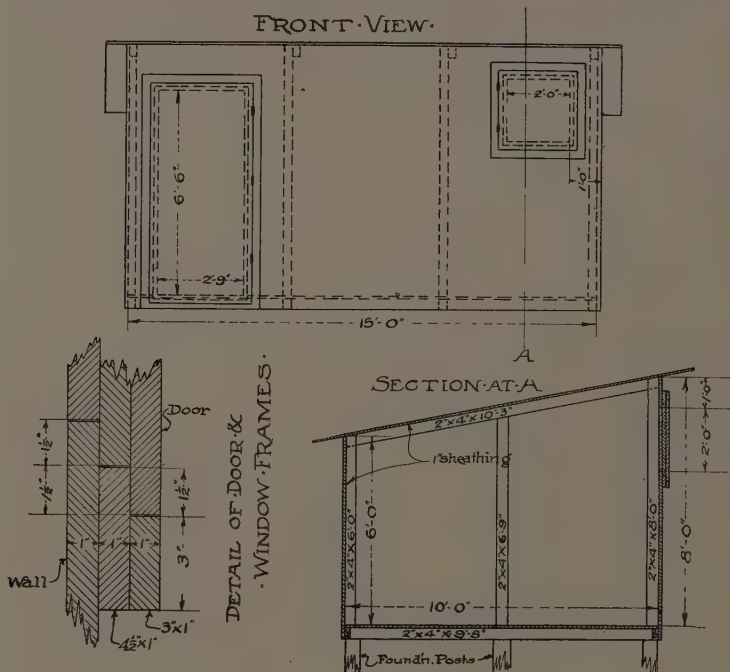


FIG. II.

after being used for fumigating purposes. A structure of the dimensions given contains slightly over a thousand cubic feet and will treat a considerable quantity of seed.

A more permanent structure, and one adapted to a wider range of uses may be made of concrete, and we include specifications for one type of concrete cellar. It is best to equip such a cellar with ventilators so that it may be used for the storage of fruits and vegetables. These ventilators should, of course, be so arranged that

they may be tightly closed when it is desired to use the cellar for fumigation. The specifications given are for a house containing just about a thousand cubic feet.

BUILDING THE WALLS AND FLOOR.

The most popular size for the average farm is a cellar 10 by 14 feet, inside measurements, with a self-supporting arched roof 5 feet above the floor at the sides and 7 feet, 8 inches in the center. All of the side walls are 8 inches thick, therefore dig the hole 11 feet, 4 inches, by 15 feet, 4 inches and to the depth desired, usually 5 feet. At one end cut out the earth to a width of 4 feet, 4 inches



FIG. 12. CONCRETE FUMIGATING HOUSE.

and slope it upward for seven concrete steps with a rise of 8 inches and a tread of 10 inches, and for a thickness of 4 inches of concrete back of the steps proper. Arrange for an 18-inch landing at the bottom of the stair.

Make the side wall forms of 1-inch siding on 2 by 4-inch uprights, spaced 2 feet. As the concrete floor will be 4 inches thick, set up the forms on 4-inch concrete bricks. Above ground level use out-

NOTE: The illustrations and description of the concrete cellar have been furnished by the Association of Portland Cement Manufacturers, Land Title Building, Philadelphia, Pa.

side forms similar to the inside. To curve the end wall forms, lay them out with a 6-foot string in the same way as described below for arch rings. At the entrance end, to provide for a doorway, set between the forms a frame of 2 by 8-inch stuff, 3 by 7 feet in the clear. Mix the concrete 1 part Portland cement to 4 parts bank-run gravel, or 1 part cement to 2 parts sand, to 4 parts crushed rock. A sack of cement equals 1 cubic foot. With the forms in place, lay

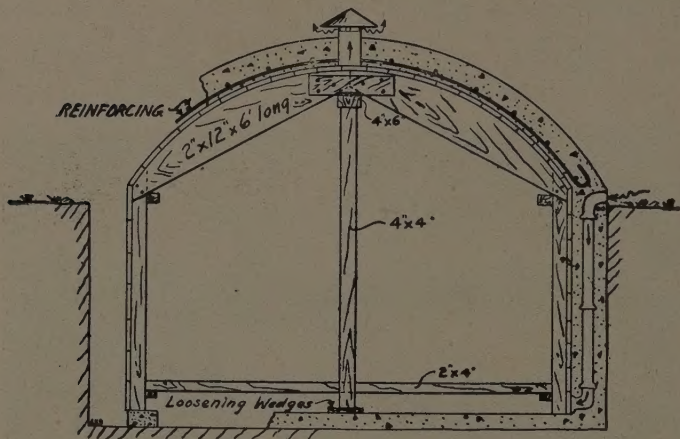


FIG. 13.

the 4-inch floor the same as a sidewalk, but without joints. Fill the wall forms in 8-inch layers with mushy, wet concrete, and 6 inches from the top of the side walls and 1 inch from the outside, place two $\frac{3}{8}$ -inch steel rods the full length of the cellar. In the concrete, two inches above the door frame, lay three 4-foot lengths of $\frac{3}{8}$ -inch rods. Roughen the top of the walls so as to insure a good bond with the roof. Build the stairway with a 4-inch thickness of concrete behind the steps proper. Each step has a tread of 10 inches and a rise of 8 inches. The side walls of the cellar hatchway extend above the door opening of the cellar proper, so that outside sloping doors may be added. In the top of the hatchway walls, while the concrete is soft, bolts are set heads down, for holding the wooden sill to which the strap hinges are later attached.

THE SELF-SUPPORTING ROOF.

When the side walls are one week old, begin on the roof. To give the roof a rise of 2 feet, 8 inches, arch rings are needed. For laying out the rings, choose a floor or a bit of level ground. To one end of a strong string fasten a pencil and tie the other end to a nail driven firmly in the floor, with exactly 5 feet, 11 inches of string between the pencil point and nail. Mark out half a circle. Across the circle lay a board exactly 10 feet long so that its ends just touch the mark. The part of the circle above the board represents the arched inside of the roof. Place boards for the arch rings over the mark on the floor and nail them together. Mark the curve upon them and cut them to the mark. Brace the arch well as shown in the drawing. Spacing the rings 2 feet apart, six will be needed. Fasten them securely in place to 2 by 6-inch liners spiked to the side wall forms. Cover the rings tightly with 1-inch sheathing.

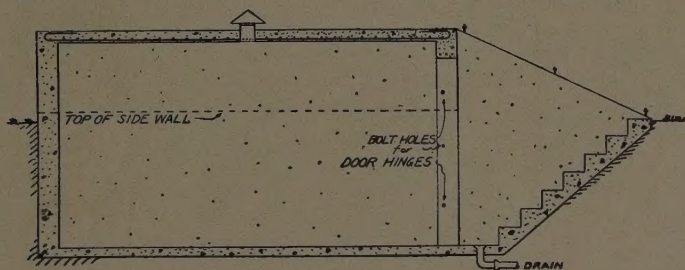


FIG. 14.

With the roof form ready, place the reinforcement upon it. Use $\frac{3}{8}$ rods, 14 feet long. Space them 6 inches apart, crosswise, and 12 inches the long way of the cellar. Wire the rods together where they cross. The roof must be 5 inches thick. Carefully work exactly 1 inch of concrete between the rods and the sheathing. Tamp the concrete until the liquid cement flushes to the top, and then finish the surface smooth by means of a wooden float and steel trowel. Do not stop for anything until the roof is finished. In two or three weeks the concrete roof will be strong enough to support itself; then the forms may be removed.

Ventilation is necessary for most cellars. While building the wall make one or more air shafts (similar to a chimney flue) of

3-inch tile, by imbedding them in the concrete wall, with an opening inside at floor level and another outside, well above ground line. By this arrangement fresh air is admitted. Place a tile chimney in the concrete roof and cover it with a galvanized iron hood for removing the foul air. If built late in the fall, protect the fresh concrete from freezing by covering it with clean straw or with old carpet so suspended as to leave a dead air space between the concrete and the covering.

Below is given a list of the materials required. The prices are higher than in most localities. If good screened pit gravel is used, no sand will be needed.

BILL OF MATERIALS.*

Crushed Rock, 13 cu. yds. at \$1.10	\$14 30
Sand, 6½ cu. yds. at \$1.00	6 50
Portland Cement, 22 bbls. at \$2.50	55 00
Rods, 40 pieces, ⅜" x 14', 206 lbs. at \$0.02¼	4 65
Total	\$80 45

* Consult local dealer for prices.